

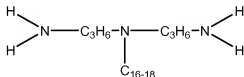
REMARKS

Claims 42 and 59-61 have been amended. The amendment to claim 42 conforms the description of surfactant formula (5) to the specification and the description of that surfactant in claim 1.

Claims 3-8, 10, 12-40, 42-47, 49 and 51-61 are pending in the application.

Previous Election

Following the Office communications dated March 9, 2007 and June 18, 2007 and applicants' election and responses filed April 5, 2007 and August 17, 2007, it is the applicants' understanding that the pending claims have been examined at least as far as they read on an aqueous pesticidal composition comprising a cationic surfactant composition comprising (i) at least one elected etheramine surfactant of formula (5), wherein R^1 is C_{13} alkyl, R^2 is C_3 alkylene, R^3 and R^4 are $-(R^6O)_xR^7$ wherein R^6 is C_2 alkylene and R^7 is hydrogen, and total x is 5 and (ii) at least one elected triamine surfactant of formula (27), wherein R^1 is tallow (i.e., C_{16-18} alkyl), R^2 , R^3 , R^4 and R^5 are each hydrogen, and x and y are each 2. Elected formula (27) therefore has the following structure:



Rejection Under 35 U.S.C. §103(a)

Pending claims 3-8, 10, 12-40, 42-47, 49 and 51-61 stand rejected under 35 U.S.C. §103(a) based on the combined teachings of U.S. Patent No. 6,607,666 (Hasebe et al.) and U.S. Patent No. 5,750,468 (Wright et al.).

Applicants submit that Hasebe and Wright, either individually or in combination, do not teach or suggest the desirability of, nor motivate one skilled in the art to obtain the claimed invention including a cationic surfactant composition comprising a first surfactant selected from a Markush group including the elected etheramine surfactant of formula (5), and a second surfactant selected from a Markush group including the elected triamine surfactant of formula (27).

As described at page 13, line 22 to page 14, line 12 of the specification, that it has been discovered that a second surfactant (e.g., certain diamines, triamines or polyamines) may function as a compatibilizer (i.e., hydrotape) in a composition containing a pesticide and a first surfactant (e.g., an etheramine surfactant) and stabilize the composition against phase separation. Because the second surfactant can stabilize pesticidal compositions, the need to add a non-surfactant stabilizer may be eliminated. It has been further discovered that the second surfactant may also function as a pesticidal efficacy enhancer. The efficacy enhancement of the combination of the first and second surfactants has been discovered to be as effective as a similar amount of the first surfactant alone. Therefore, one aspect the present invention provides for the addition of a second surfactant to pesticidal compositions that advantageously functions as both a stabilizer and a herbicidal efficacy enhancer. The net result is: (1) a reduction in excipient loading by virtue of the elimination of the

requirement for a non-surfactant hydrotape; (2) concentrated pesticidal compositions having a level of stability and a pesticide concentration that could not be attained in the absence of the second surfactant; and (3) pesticidal efficacy comparable to compositions known in the art.

Wright describes herbicidal compositions comprising glyphosate or a salt thereof and certain etheramine surfactants, including alkoxyated tertiary etheramines, alkoxyated or non-alkoxyated quaternary etheramines and alkoxyated etheramine oxides. Some of the specific etheramine surfactants disclosed by Wright fall within formula (5) as defined in the pending claims.

Wright is silent regarding alkoxyated triamine surfactants of formula (27).

Hasebe describes an enhancer composition for agricultural chemicals comprising (A) at least one nitrogen containing surfactant compound selected from the group consisting of a tertiary amine, a tertiary amine salt and a quaternary ammonium salt and (B) a chelating agent (See abstract and at col. 2, lines 15-26). Hasebe asserts that the efficacy of an agricultural chemical can be enhanced by using a chelating agent at high dose together with the tertiary amine, tertiary amine salt or quaternary ammonium salt surfactant (See col. 17, lines 51-56). That is, contrary to the assertion on page 2 of the Office action, the chelating agent does not enhance the effectiveness of the agricultural chemical, but it is the combination of the chelating agent in high dose with the disclosed tertiary amines or quaternary ammonium salt surfactants purported to provide increased efficacy.

Hasebe is silent regarding etheramine surfactants of formula (5).

The Office refers to the disclosure at col. 15, line 57 to col. 16, line 42 of Hasebe regarding the chelating agent of the enhancer composition, and in particular the triamine structure set forth under item (f). In support of its rejection, the Office contends that the triamine chelating agent described by Hasebe is a surfactant. It is respectfully submitted that the Office has impermissibly failed to offer any evidence in support of this contention. Under the MPEP examination guidelines: "Official notice unsupported by documentary evidence should only be taken by the examiner where the facts asserted to be well-known, or to be common knowledge in the art are capable of instant and unquestionable demonstration as being well-known." quoting MPEP §2144.03A. Contrary to the Office's contention, applicants submit that it is common general knowledge possessed by a person of ordinary skill in the art that the Hasebe triamine chelating agent could not also be a surfactant. In particular, it is well known to those skilled in the art that surfactants comprise groups of opposing solubility tendencies: (i) a water-soluble (i.e., hydrophilic) ionic group and (ii) an oil-soluble (i.e., hydrophobic) hydrocarbon chain. See Kirk-Othmer, Concise Encyclopedia of Chemical Technology (4th Ed. 1999), pages 1949-50 (copy appended at the end of this response). See also, among many others, U.S. Patent Nos. 4,219,436, 4,261,851, 4,443,600, 4,560,599, 5,084,212, 5,277,899, 5,360,571, 5,436,008, 5,911,981 and 6,277,788 where surfactants are described as compounds comprising a hydrophilic and a hydrophobic group. The Hasebe triamine chelating agent consists of five water-soluble (hydrophilic) ionic carboxyl groups, but does not have an oil-soluble hydrophobic group. Therefore, one skilled in the art would understand that the Hasebe triamine chelating agent is not a surfactant as called

for in the cationic surfactant composition of the claimed invention.

Moreover, aside from the fact that the triamine structure set forth under item (f) at col. 16, lines 17-25 of Hasebe does not function as a surfactant, it is listed as one example of an aminopolycarboxylic acid chelating agent along with compounds represented by the chemical formulae (a) RNX_2 ; (b) NX_3 ; (c) $R-NX-CH_2CH_2-NX-R$; (d) $R-NX-CH_2CH_2-NX_2$; and (e) $X_2N-R'-NX_2$. None of these other structures are triamines. Hasebe goes on to teach that the chelating agent used in the enhancer composition is not particularly restricted, so long as it is capable of chelating a metal ion and includes not only aminopolycarboxylic acids of structures (a)-(f), but also aromatic or aliphatic carboxylic acid chelating agents, amino acid chelating agents, ether polycarboxylic acid chelating agents, phosphonic acid chelating agents such as iminodimethylphosphonic acid (IDP) and alkyldiphosphonic acid (ADPA), hydroxy carboxylic acid chelating agents, electrolyte chelating agents of polymer (including oligomer) type, and dimethylglyoxime (DG). The chelating agents may be in the form of either an acid or a salt such as sodium salt, potassium salt and ammonium salt or in the form of an ester derivative thereof which can be hydrolyzed (See col. 15, line 58 to col. 16, line 5).

Among this vast collection of suitable chelating agents, Hasebe contains no teaching whatsoever of a preference for aminopolycarboxylic acids generally and the triamine of structure (f) in particular. Rather, Hasebe specifically excludes aminopolycarboxylic acids from the listing of preferred chelating agents.

"Among the above-mentioned chelating agents, preferable ones include aliphatic carboxylic acid chelating agents, aromatic carboxylic acid chelating agents, hydroxy carboxylic acid chelating agents, amino acid chelating agents, ether polycarboxylic acid chelating agents, phosphonic acid chelating agents, electrolyte chelating agents of polymer (including oligomer) type, dimethylglyoxime (DG), ascorbic acid and thioglycollic acid, and salts of ascorbic acid and thioglycollic acid. Among them, aliphatic carboxylic acid chelating agents, aromatic carboxylic acid chelating agents, hydroxy carboxylic acid chelating agents, amino acid chelating agents and ether polycarboxylic acid chelating agents are still more preferable." (See col. 17, lines 19-31)

The Office has not provided any basis in the teaching of Hasebe that would direct or suggest to one skilled in the art to select a triamine chelating agent over all the other innumerable and more preferred chelating agents disclosed in the reference for possible combination in aqueous pesticidal compositions containing a surfactant other than the disclosed certain tertiary amine, tertiary amine salt or quaternary ammonium salt surfactants, such as the etheramine surfactant compositions disclosed by Wright.

As a purported basis for the combination with Hasebe, the Office refers and partially quotes the disclosure at col. 8, lines 26-34 of Wright. The entire text of Wright at col. 8, lines 26-34 is set forth below:

"In addition to glyphosate or a salt thereof and the etheramine surfactant, any of a variety of further ingredients or adjuvants may be included in formulations of the present invention as long as such added materials are not significantly antagonistic to the glyphosate herbicidal activity. Examples of such added materials illustratively include anti-gelling agents, antifreezes, thickeners, dyes, antimicrobial preservatives or additives to further enhance herbicidal activity, such as ammonium sulfate or fatty acids."

When read in context, the mention of "additives to further enhance herbicidal activity, such as ammonium sulfate or fatty acids," is only a general reference regarding possible additives. Such a generalized statement includes a virtually unlimited set of potentially herbicidal activity-enhancing additives that are known in the art and the reference to ammonium sulfate or fatty acids cannot reasonably be said to motivate or direct one skilled in the art to the teaching of Hasebe, much less select the triamine chelating agent of Hasebe from the myriad of other disclosed and more preferred chelating agents.

The Office suggests that "the ordinary artisan would have been motivated to combine multiple ingredients (glyphosate, chelating agent, etheramine) as taught in the references in order to take advantage of the characteristics provided by the surfactants." The Office fails to articulate what those characteristics might be. Surfactants, such as the etheramine surfactant of Wright, are generally intended to enhance pesticidal activity, but that does not motivate one skilled in the art to combine surfactants. Similarly, the purported advantageous characteristic of the chelating agents in Hasebe is the efficacy enhancement of an agricultural chemical when used at high dose together with the certain tertiary amine, tertiary amine salt or quaternary ammonium salt surfactants disclosed therein.

"The mere fact that references can be combined or modified does not render the resultant combination obvious unless the prior art also suggests the desirability of the combination" (See MPEP §2143.01). Moreover, "[t]o support the conclusion that the claimed invention is directed to obvious subject matter, either the references must expressly or impliedly

suggest the claimed combination or the examiner must present a convincing line of argument as to why the artisan would have found the claimed invention to have been obvious in light of the teaching of the references" (See MPEP §2142). Nothing in the disclosure of Wright or Hasebe teaches or suggests the claimed combination and the Office action does not articulate a reasonable basis upon which these references would direct the skilled person to a cationic surfactant composition comprising the elected etheramine surfactant of formula (5) and select a co-surfactant comprising the elected triamine surfactant of formula (27) to function as a compatibilizer or hydrotrope in an aqueous pesticidal composition so as to attain higher pesticide loadings in a stable concentrate while maintaining pesticidal efficacy.

In view of the above, it is respectfully submitted that the Office has not met its initial burden of establishing a *prima facie* case of obviousness with respect to the invention defined in independent claims 3 and 42. Claims 4-8, 10, 12-40, 52, 53, and 56-58 which depend directly or indirectly from claim 3, and claims 43-47, 49, 51, 54, 55 and 59-61, which depend directly or indirectly from claim 42, are likewise submitted as patentable over the cited art for the reasons stated with respect to claims 3 and 42 and for the additional features set forth therein.

Favorable reconsideration and allowance of all pending claims are respectfully requested.

The Commissioner is hereby authorized to charge the fee for a one-month extension of time up to and including March 2, 2008 and any other fees in connection with this response to Deposit Account No. 19-1345.

The Examiner is invited to contact the undersigned attorney should any issues remain unresolved.

Respectfully submitted,

A handwritten signature in cursive script, appearing to read "James Harper".

James D. Harper, Reg. No. 51,781
SENNIGER POWERS
One Metropolitan Square, 16th Floor
St. Louis, Missouri 63102
(314) 231-5400

JDH/VMK/mrt
*Attachment

KIRK-OTHMER

CONCISE ENCYCLOPEDIA OF CHEMICAL TECHNOLOGY

4th EDITION



A WILEY-INTERSCIENCE PUBLICATION

John Wiley & Sons, Inc.

NEW YORK • CHICHESTER • WEINHEIM • BRISBANE • SINGAPORE • TORONTO

Copyright © 1999 by John Wiley & Sons, Inc.

Paper edition published 2001.

All rights reserved. Published simultaneously in Canada.

Reproduction or translation of any part of this work beyond that permitted by Section 107 or 108 of the 1976 United States Copyright Act without the permission of the copyright owner is unlawful. Requests for permission or further information should be addressed to the Permission Department, John Wiley & Sons, Inc.

Library of Congress Cataloging-in-Publication Data

Kirk-Othmer concise encyclopedia of chemical technology.—4th ed.

p. cm.

Executive editor, J. Kroschwitz.

"A Wiley-Interscience publication."

Abridged version of the 26 volume Kirk-Othmer Encyclopedia of chemical technology, 4th ed. New York: Wiley, c1991-c1998.

Includes index.

ISBN 0-471-29698-8 (cloth); ISBN 0-471-41961-3 (paper)

I. Chemistry, Technical—Encyclopedias. I. Kroschwitz, Jacqueline L. II. Encyclopedia of chemical technology. III. Title: Encyclopedia of chemical technology. IV. Title: Concise encyclopedia of chemical technology.

TP9.K54 1999

660'.03—dc 21

98-50686

CIP

Printed in the United States of America

components of an electron spectrometer system are the source, the electron energy analyzer, and the electron detector.

Xps requires a source that can provide a single x-ray line reasonably narrow in energy. The absolute energy requirement for this x-ray line is that it must be energetic enough to generate photoelectrons from core levels of a majority of the elements with reasonable resolution.

The most common detector for electron spectroscopy is the channel electron multiplier. The raw currents encountered for surface-ejected electrons in a typical xps or aes experiment are on the order of 10^{-14} to 10^{-16} A, far too low to be measured directly. When electrons emerging from the analyzer impinge on the inside surfaces of the electron multiplier, multiple electrons are ejected. Electron amplification on the order of 10^3 to 10^6 is achieved making the currents produced by the electron multiplier easily measurable.

Electron Microprobe Analysis. Electron microprobe analysis (ema) is a technique based on x-ray fluorescence from atoms in the near-surface region of a material stimulated by a focused beam of high energy electrons. Essentially, this method is based on electron-induced x-ray emission as opposed to x-ray-induced x-ray emission, which forms the basis of conventional x-ray fluorescence (xrf) spectroscopy. Ema usually refers to a stand-alone instrument for electron-induced x-ray analysis in either the edx or wavelength dispersive x-ray spectroscopy mode (wds). Ema is used for the determination of elemental constituent identification due to the dependence of x-ray energy on atomic number (Z) of the atom from which the x-ray originates. Ema is also commonly employed for compositional mapping of elements across a surface. Ema can provide elemental maps of both major and minor constituents at detectabilities of a few hundred parts per million in the best cases. This elemental mapping can be accomplished with a lateral resolution of ca 1 μ m.

Analysis of Surface Molecular Composition. There is a variety of methods available for elucidating the nature of the molecules that exist on a surface or within an interface.

The most common and readily accessible methods are those based on far spectroscopy.

Transmission Fourier Transform Infrared Spectroscopy. Transmission ftir spectroscopy is most often used to study surface species on metal oxides. These solids leave reasonably large spectral windows within which the spectral behavior of the surface species can be viewed. The advantage of this approach for characterization of surface species is the ease of sample preparation and straightforward data interpretation. Spectra of such samples resemble normal transmission ir spectra and can be quantitated using conventional methods.

Diffuse Reflectance Infrared Fourier Transform Spectroscopy. An alternative approach to the acquisition of surface ir spectra for particulate or powdered samples is diffuse reflectance infrared Fourier transform spectroscopy (drifts). The technique is based on the diffuse reflectance of radiation that occurs when it is directed onto a surface with a matte finish or a sample comprised of a powder. This diffuse reflectance is different than specularly reflected radiation in that it penetrates and interacts with a sample before emerging.

The amount of diffusely reflected light cannot be measured directly; instead, it is typically measured relative to a nonabsorbing reference material to allow adequate correction for scattering characteristics of the powdered sample. The signal that is measured is the ratio of the diffuse reflectance of the sample to that of a nonabsorbing reference material.

Attenuated Total Reflectance Fourier Transform Infrared Spectroscopy. Attenuated total reflectance (atr) ftir spectroscopy is based on the principle of total internal reflection. The implementation of internal reflection in the ir region of the spectrum provides a means of obtaining ir spectra of surfaces or interfaces, thus providing molecularly-specific vibrational information.

Infrared Reflection-Absorption Spectroscopy. For adsorbed surface species or thin films on ir reflective surfaces such as metals, an alternative method is infrared reflection-absorption spectroscopy (irras). This technique is based on the external reflection on an infrared beam of light at such surfaces, the characteristics of which are highly

polarization dependent. Upon reflection of a polarized beam of light at a surface, phase shifts occur that can be quite significant in magnitude. Given that the electric field experienced by a molecule at a reflective surface equals the sum of the fields from the incident and reflected beams, the magnitude of this phase shift is critical in determining the resulting light intensity available with which a surface molecule can couple.

The ir spectra acquired in this way are extremely sensitive to the orientation of the surface molecules. Molecules must have a significant component of a molecular vibration perpendicular to the surface to be sensed by coupling with the highly directional electric field. Molecules whose dipole moments are perfectly parallel to the surface cannot couple to the existing electric fields, and therefore, are ir transparent by this method. This selectivity of the approach for molecule dipole moments perpendicular as opposed to parallel to the surface is known as the surface selection rule of iras.

This approach works quite well for species at metal surfaces. It has been used extensively to ascertain information about organic thin films on metal surfaces. Of particular interest in many of these studies has been the determination of molecular orientation on surfaces from such studies. Few other techniques are quite so useful for unambiguously ascertaining molecular orientation.

JEANNE E. PEMBERTON
University of Arizona

B. W. Roelster and R. C. Baetzold, eds., *Investigations of Surfaces and Interfaces, Part A. Physical Methods of Chemistry*, Vol. 9A, 2nd ed., John Wiley & Sons, Inc., New York, 1993.

C. R. Brundle and A. D. Baker, eds., *Electron Spectroscopy: Theory, Techniques and Applications*, Vol. 4, Academic Press, New York, 1981.

D. J. Connor, B. A. Sexton, and R. St. C. Smart, eds., *Surface Analysis Methods in Materials Science, Springer Series in Surface Sciences*, Vol. 23, Springer-Verlag, Berlin, 1992.

J. C. Riviere, *Surface Analytical Techniques. Monographs on the Physics and Chemistry of Materials*, Oxford University Press, New York, 1990.

SURFACTANTS

The term surfactant, contraction of surface-active agent, is used to describe organic substances having certain characteristics in structure and properties. The term detergent is often used interchangeably with surfactant. As a designation for a substance capable of cleaning, detergent can also encompass inorganic substances when these do in fact perform a cleaning function. More often, however, detergent refers to a combination of surfactants and other substances, organic or inorganic, formulated to enhance functional performance, specifically cleaning, over that of the surfactant alone. It is so used herein.

Surfactants are characterized by the following features. Amphipathic structure: surfactant molecules are composed of groups of opposing solubility tendencies, typically an oil-soluble hydrocarbon chain and a water-soluble ionic group; solubility: a surfactant is soluble in at least one phase of a liquid system; adsorption at interfaces: at equilibrium, the concentration of a surfactant solute at a phase interface is greater than its concentration in the bulk of the solution; orientation at interfaces: surfactant molecules and ions form oriented monolayers at phase interfaces; micelle formation: surfactants form aggregates of molecules or ions called micelles when the concentration of the surfactant solute in the bulk of the solution exceeds a limiting value, the so-called critical micelle concentration (CMC), which is a fundamental characteristic of each solute-solvent system; and functional properties: surfactant solutions exhibit combinations of cleaning (detergency), foaming, wetting, emulsifying, solubilizing, and dispersing properties.

The presence of two structurally dissimilar groups within a single molecule is the most fundamental characteristic of surfactants. The surface behavior (surface activity) of the surfactant molecule is deter-

mined by the makeup of the individual groups, solubility properties, relative size, and location within the surfactant molecule.

Different designations describe the opposing groups within the surfactant molecules, eg, hydrophobic (water hating) and hydrophilic (water liking), lipophobic (fat hating) and lipophilic (fat liking), oleophobic (oil hating) and oleophilic (oil liking), and lyophobic (solvent hating) and lyophilic (solvent liking). The terms polar and nonpolar are also used to designate water-soluble and water-insoluble groups, respectively.

Surface activity is not limited to aqueous systems; however, because water is present as the solvent phase in the overwhelming proportion of commercially important surfactant systems, its presence is assumed in much of the common terminology of industry. Thus, the water-soluble amphipathic groups are often referred to as solubilizing groups.

Surfactants are classified depending on the charge of the surface-active moiety. In anionic surfactants, this moiety carries a negative charge. In cationic surfactants, the charge is positive. In nonionic surfactants, there is no charge on the molecule, the solubilizing contribution can be supplied by side groups. Finally, in amphoteric surfactants, solubilization is provided by the presence of positive and negative charges in the molecule. In general, the hydrophobic group consists of a hydrocarbon chain containing ca 10–20 carbon atoms. The chain may be interrupted by oxygen atoms, a benzene ring, amides, esters, other functional groups, and/or double bonds. A propylene oxide hydrophobe can be considered a hydrocarbon chain in which every third methylene group is replaced by an oxygen atom. In some cases, the chain may carry substituents, most often halogens. Siloxane chains have also served as the hydrophobe in some surfactants.

Hydrophilic, solubilizing groups for anionic surfactants include carboxylates, sulfonates, sulfates, and phosphates. Cationic are solubilized by amine and ammonium groups. Ethylene oxide chains and hydroxyl groups are the solubilizing groups in nonionic surfactants. Amphoteric surfactants are solubilized by combinations of anionic and cationic solubilizing groups.

The molecular weight of surfactants may be as low as ca 200 up to the thousands for polymeric structures. A surfactant with a straight-chain C_{12} -hydrophobe and a solubilizing group is generally an effective structure. The optimum can be higher by several carbon atoms or even slightly lower than 12 depending on the nature of the polar group and the desired function of the surfactant.

In the application of surfactants, physical and use properties, precisely specified, are of primary concern. Chemical homogeneity is of little significance in practice. In fact, surfactants are generally polydisperse mixtures, such as the natural fats as precursors of fatty acid-derived surfactant structures; eg, coconut oil contains glycerol esters of C_8 – C_{18} fatty acids. Nonionic surfactants of the alcohol ethoxylate type are polydisperse not only with respect to the hydrophobe but also in the number of ethylene oxide units attached.

Commercial surfactants are complicated mixtures exceedingly difficult to separate into pure molecular species.

Physical Chemistry of Interfaces

The usefulness of surfactants stems from the effects that they exert on the surface, interfacial, and bulk properties of their solutions and the materials their solutions come in contact with.

Phenomena at Liquid Interfaces. The area of contact between two phases is called the interface; three phases can have only a line of contact, and only a point of mutual contact is possible between four or more phases. Combinations of phases encountered in surfactant systems are L–G, L–L–G, L–S–G, L–S–S–G, L–L, L–L–L, L–S–S, L–L–S–S–G, L–S, L–L–S, and L–L–S–S–G, where G = gas, L = liquid, and S = solid. An example of an L–L–S–S–G system is an aqueous surfactant solution containing an emulsified oil, suspended solid, and entrained air (see EMULSIONS; FOAMS). This embodies several conditions common to practical surfactant systems. First, because the



Figure 1. (a) Gas-liquid (GL) interface; (b) liquid-liquid (LL) interface.

surface area of a phase increases as particle size decreases, the emulsion, suspension, and entrained gas each have large areas of contact with the surfactant solution. Next, because interfaces can exist only between two phases, analysis of phenomena in the L–L–S–G system breaks down into a series of analyses, ie, surfactant solution to the emulsion, solid, and gas. It is also apparent that the surfactant must be stabilizing the system by preventing contact between the emulsified oil and dispersed solid. Finally, the dispersed phases are in equilibrium with each other through their common equilibrium with the surfactant solution.

Figures 1a and 1b represent typical gas-liquid and liquid-liquid interfaces at equilibrium. Assuming that gas, G, consists of air and vapor of the liquid, L, at equilibrium, there is continuous movement of liquid molecules through the gaseous interfacial region R_0 because rates of evaporation and condensation at the interface I_0 are equal (Fig. 1). Liquid molecules are also moving continuously into and out of I_0 through the liquid interfacial region. R_1 , R_0 , and R_2 represent nonhomogeneous transitional regions between the homogeneous phases, and L systems are known in which R_0 and R_1 have thicknesses equivalent to two or more layers of molecules, but for most analyses the interface I_0 can be considered as consisting of a single layer of molecules.

For thermodynamic treatment of surface phenomena, the thickness of the boundary regions can often be ignored or their effect eliminated by selection of a convenient location for the interface I_0 . The liquid-liquid interface, I_{LL} (Fig. 1b) is similarly associated with interfacial regions, R_1 and R_2 , which can be treated like the gas-liquid interface in most analyses. Because few liquids are completely immiscible, mutual saturation is taken as the equilibrium condition.

Energy of Adhesion. The interfacial energy between two mutually insoluble saturated liquids, A and B, is equal to the difference in the separately measured surface energies of each phase: $\gamma_{AB} = \gamma_A - \gamma_B$, where γ is free-surface or interfacial energy. The term γ_{AB} represents the energy that must be added to the system to separate the liquids.

Contact Angle. The line of contact between the three phases of a G–L–S system is the locus of all points from which the angle of contact between the liquid and the solid can be measured. The drop of liquid, L, is resting on the solid, S, and both phases are exposed to the gas, G, at equilibrium saturation of the liquid in air (gas). The drop is assumed to be small enough for the flattening pressure of gravity to be negligible. The vector X_0 is tangent to the liquid at its contact with the solid. The angle between the tangent and the surface of the solid is called the contact angle, θ . The equilibrium value of θ is an indicator of the energy relationships between liquid-liquid and liquid-solid interfaces.

Effects of Surfactants on Solutions. A surfactant changes the properties of a solvent in which it is dissolved to a much greater extent than is expected from its concentration effects. This marked effect is the result of adsorption at the solution's interfaces, orientation of the adsorbed surfactant ions or molecules, micelle formation in the bulk of the solution, and orientation of the surfactant ions or molecules in the micelles, which are caused by the amphipathic structure of a surfactant molecule. The magnitude of these effects depends to a large extent on the solubility balance of the molecule. An efficient surfactant is usually relatively insoluble as individual ions or molecules in the bulk of a solution.

Positive adsorption, the concentration of one component of a solution at a phase boundary, results in a lowering of the free-surface